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Gear system for drive of a multi-shaft extruder

The invention relates to a gear system for the drive of an extruder according to the generic part of claim 1.

The advantage of these multi-shaft extruders with spiral shafts around the rim as compared with a two-shaft extruder is that they have twice as many wedge-shaped regions in which the product is processed particularly effectively when transferred by the conveyor elements from one shaft to the next.

The power of the multi-shaft extruder is critically dependent on the torque provided by the gear system. The maximum power of the gear system is significantly affected by the narrow gap between the shafts. The power of a gear system is expressed by an indicator calculated as the ratio of the torque to the shaft gap in  $\text{cm}^3$ .

EP 0788867 B1 describes a known gear system for a multi-shaft extruder according to the generic part of claim 1. The power limit of the gear system of the known multi-shaft extruder is currently around  $6 \text{ Nm/cm}^3$  per shaft.

The objective of the invention is to significantly increase the power of a gear system for a multi-shaft extruder.

According to the invention, this is achieved with the gear system characterized in claim 1. The dependent claims describe advantageous embodiments of the invention.

According to the invention, every first and every second pinion is axially offset and is driven both partly from the inside by a central, externally-toothed drive wheel and from the outside by the surrounding internally-toothed hollow gear wheel, with the same torque in each case.

Because of the small gap between them, the driven shafts of the gear system for the multi-shaft extruder must be formed with a correspondingly small diameter. They are therefore loaded to the maximum. Hence a high torque can only be achieved if no transverse or similar forces are acting on the driven shafts. According to the invention, this is ensured by means of the internally-toothed hollow gear wheel, which is driven with the same torque as the externally-toothed drive wheel. The radial forces acting on the pinion thus cancel one other out.

A drive for the central, externally-toothed drive wheel and the surrounding internally-toothed hollow gear wheel with the same power can be implemented in various ways. For example, two separate motors with suitable electronic control can drive the externally-toothed central drive wheel and the internally-toothed hollow gear wheel with the same torque. Another possibility is to provide a differential gear between the main drive shaft of the gear system and the externally-toothed central drive wheel on the one hand, and the surrounding internally-toothed hollow gear wheel on the other, which distributes

half of the torque of the main drive shaft to the externally-toothed central main drive wheel and half to the internally-toothed hollow gear wheel.

An embodiment of the gear system according to the invention is now explained on the basis of the drawing.  
In the drawing:

Figure 1 shows a longitudinal section through the process part of a multi-shaft extruder;

Figure 2 shows a cross-section along line II-II in Figure 1;

Figure 3 shows a longitudinal section through the gear system to the drive for the multi-shaft extruder;

Figures 4 and 5 show a cross-section along lines IV-IV and V-V in Figure 3; and

Figure 6 shows an enlarged detailed view of the coupling and branching bush according to Figure 3.

As shown in Figures 1 and 2, the processing part 1 of the extruder, in a housing 2a with a core 2b, has axially parallel shafts 3, rotating in the same direction, arranged around a circle (Figure 2) at equal angles with respect to each other, which are equipped with the conveyor elements 4, wherein the conveyor elements 4 of adjacent shafts engage with each other.

The processing part 1 is sealed on its two face ends with end plates 5 and 6. Shafts 3, which are driven in rotation in the same direction by the branching gear

system 7 extend through the end plate on the conveyor side.

As shown in Figures 3 to 6, the branching gear system is connected via a plate 9 with the end plate 5 of the processing part 1.

Twelve driven shafts 11 extend from the branching gear system 7, on the side facing the processing part 1. These are coaxially and connected in a torque-proof manner with the twelve shafts 3 of the processing part 1. On the side facing away from the processing part 1 the branching gear system 7 is flanged onto the reducer gear system 12 via the connection housing 8; a main drive shaft 13 extends from the reducer gear system 12 into the connector housing 8. The reducer gear system 12 is driven by a motor, not shown.

Via the coupling and branching bush 40, the main drive shaft 13 drives a drive shaft 14, located coaxially inside it, and four externally located axially parallel drive shafts 15 to 18.

The driven shafts 11 and the pinions 19, 20 are made from a single piece. Because of the small axial gap between the driven shafts 11, the pinions 19, 20 of adjacent shafts 11 are axially offset. This means that the pinions 19 are located closer to the processing part 1 than the pinions 20.

Accordingly, the central drive shaft 14 is provided, in a torque-free manner, with two axially offset internally-located externally-toothed drive wheels 21, 22, which engage with the pinions 19, 20.

The pinions 19, 20 are driven by both the central, externally-toothed drive wheels 21, 22 and the surrounding internally-toothed hollow gear wheel 24, 25 arranged radially opposite them, with the hollow gear wheels 24 and 25 also being axially offset accordingly.

Each hollow gear wheel 24, 25 has an outside tooth gearing, which engages with an externally-toothed drive wheel 26 to 29 on the four outwardly-located drive shafts 15 to 18. The outwardly-located drive wheels 26 to 29 are arranged in an axially offset fashion, in the same way as pinions 19, 20, the inwardly-located drive wheels 21, 22 and the hollow gear wheels 24, 25.

As can be seen from Figures 3, 4 and 5, this means that the two outwardly-located drive shafts 15, 17 which drive the pinions 19 located nearer the processing part 1 via the hollow gear wheel 24 are longer in form than the two outwardly-located drive shafts 16, 18 that drive the pinions 20. Since the same torque acts on the long and short outwardly-located drive shafts 15, 17 and 16, 18, the long drive shafts 15, 17 would be twisted together to a greater extent than the short drive shafts 16, 18. To equalize the rotary angle, the long drive shafts 15, 17 have a correspondingly larger diameter to ensure the precise distribution of the torque for the hollow gear wheels 24 and 25.

The hollow gear wheels 24, 25 are centered in largely force-neutral fashion by the two diametrically opposed outwardly-located drive wheels 26, 28 and 27, 29. Accordingly the radial bearings 31, 32 for the hollow gear wheels 24, 25 can be made relatively small. The

outwardly-located drive shafts 15 to 18 are supported in the housing with the radial bearings 33, 34 and 35, 36. The driven shafts 11 are supported by the axial bearings 37, 38 and the radial bearings 39.

For power branching purposes a coaxially arranged, floating bush 40 is provided to drive the inwardly-located drive shaft 14 and the outwardly-located drive shafts 15 to 18. As shown in Figure 6, the floating bush 40 has a straight outer tooth gearing 41, which engages with an inner tooth gearing 42 on the inward side of a sleeve 43 attached in a torque-proof manner to the main drive shaft 13.

In addition, the floating bush 40 has skew bevel gearings 45 to 44, opposite each other on the inward and outward side, which engage on the one hand with a skew bevel gearing 46 on the inwardly-located drive shaft 14 and on the other with a skew bevel gearing on the inward side of a hollow gear wheel 47, that is provided with an outside tooth gearing and engages via an interposed reversing wheel 48 with a toothed wheel 49, 50 on the outwardly-located drive shafts 15 to 18.

In place of the gear system shown, with the bush 40, hollow gear wheel 47, reversing wheel 48, etc., which distributes the torque of the main drive shaft 13 to the inwardly-located drive shaft 14 and the outwardly-located drive shafts 15 to 18, it is possible to use any other gear system that leads to an optimal distribution of half the power to the inwardly-located drive shaft 14 on the one hand and half to the outwardly-located drive shafts 15 to 18 on the other.

Instead of the two diametrically opposed outer drive wheels 26, 28 and 27, 29, which engage with hollow gear wheel 24 or 25, it is also possible to have three or more outwardly-located drive wheels placed at equal angles with respect to one other engaging with each hollow gear wheel 24, 25, as a result of which the hollow gear wheels 24, 25 are centered, removing the need for the bearing 31, 32 of the hollow gear wheels 24, 25.